An improved background segmentation method for ghost removals

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ABSTRACT

Video surveillance has become common for the maintenance of security in a wide variety of applications. However, the increasingly large amounts of data produced from multiple video camera feeds is making it increasingly difficult for human operators to monitor the imagery for activities likely to give rise to threats. This has led to the development of different automated surveillance systems that can detect, track and analyze video sequences both online and offline and report potential security risks. Segmentation of objects is an important part of such systems and numerous background segmentation techniques have been used in the literature. One common challenge faced by these techniques is adaption in different lighting environments. A new improved background segmentation technique has been presented in this where the main focus is to accurately segment potentially important objects by reducing the overall false detection rate. Historic edge maps and tracking results are analyzed for this purpose. The idea is to obtain an up to date edge map of the segmented region highlighted as foreground areas and compare them with the stored results. The edge maps are obtained using a novel adaptive edge orientation based technique where orientation of the edge is used. Experimental results have shown that the discussed technique gives over 85% matching results even in severe lighting changes.

Keywords: Video surveillance, background segmentation, ghost removals, ghost detection, edge based tracking, correlation

1. INTRODUCTION

Automated detection of objects is of prime importance for video surveillance and security system applications. Different background segmentation techniques have been used to segment moving object from stationary background. Some of the common techniques are Codebook model Kim *et al.* [1], Gaussian Mixture Model (GMM) based background segmentation Stauffer *et al.* [2] and Bayesian decision rules based method Li *et al.* [3]. Other methods [4-8] are also used to remove moving objects from the background. One common problem faced by all such method is detection of ghost objects. Ghost objects are created when an object has become stationary for such a long period of time that it has become part of the background model. When the object eventually moves away, the background behind the object is incorrectly classified as a foreground object, leaving a 'ghost' of the original object. An example of this is shown in figure 1. Different approaches [9-10] have been presented in the past to solve this problem. The biggest challenge faced by these methods is coping with changes in the lighting conditions. An improved edge orientation based background segmentation method has been presented in this paper to remove ghost objects from the scene. Objects are initially segmented using the GMM method. A 2-D spatial gradient measure is performed on the image using Sobel convolution operator and edges are obtained in both the vertical and the horizontal directions. The direction of the edges is calculated and similarity measure is obtained by comparing edges calculated at different point in time. The experimental results have shown that the proposed method given over 85% matching results in changing lighting conditions.

The remaining paper is organized as follows: The following section explains the computational model used to calculate the direction of the edges. Section 3 shows the experimental results of the proposed method when tested on over 6 hours of video sequence. Finally the study is concluded in section 4.

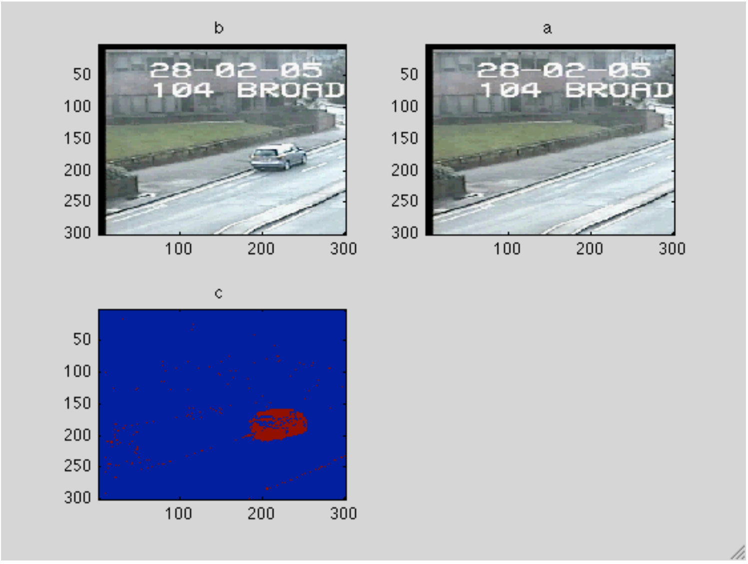


Figure 1 a) the background model with a stationary car b) the car has driven away but still remains in the background model. c) The foreground segmentation (in red) shown the car's ghost.

2. COMPUTATIONAL MODEL

The magnitude of an edge has been used extensively in literature to find the similarity between two images. Canny, Sobel, and Prewitt are some of the well know methods used for this purpose. Edges are points in an image with sharp changes in intensity and often represent an object's unique features. One of the important characteristics of edges are that they are less sensitive to changes in illumination. A new method has been presented in this paper that uses the similarity results between the edge map of same image but taken at different point in time to remove ghost objects from background segmentation results.

A GMM is initially used to segment foreground objects from the background. One of the main drawbacks of GMM or in this case any other background segmentation method is that they are sensitive to sudden changes in lighting conditions. This result in background areas becoming falsely highlighted as foreground objects. This can cause serious issues in video surveillance applications. In order to remove false background regions identified as part of foreground, a new edge based technique has been developed that uses the direction of the edge instead of magnitude to measure the similarity scores to rectify this problem.

A 2-D spatial gradient measure is performed on an image, where *I* is the monochrome image intensity. This is performed by a 3x3 Sobel convolution operator and it is used to find the edges in both the vertical and the horizontal directions. So that the edge directions are well defined, the magnitude of the gradient is then calculated at time *T*. This is done by taking the square root of the sum of the squares of each direction gradient and becomes a set of pixels Θ_n^T . Finally the output of the magnitude is thresholded to form a subset of coordinates, M_n . A low threshold is chosen such that most of the edges are preserved.

The direction of the gradient of each member of M_n is then calculated by taking the arctangent of the ratio the vertical and horizontal gradients. It is denoted as $\Phi_{M_n}^T$, where $\Phi_{M_n}^T$ can range between 0 to 360 degrees.

The obtained angles are then used to calculate a metric that gives a measure of the degree of correlation between an image at the current time *t* and the historic time *T*.. For the n^{th} image this is the real component of:

$$C_n^t = \sum_{M_n} \frac{\exp\left(i\Phi_{M_n}^{t}\right)\exp\left(-i\Phi_{M_n}^{T}\right)}{\left|M_n^T\right|} \tag{1}$$

where the vertical bars represent the cardinality of the set, and T is the time at which the reference edge mask is produced. The expression obtained above is the generalized correlation equation used in the proposed method for template matching. Since the location of the foreground object is known, the overall computational time is reduced by avoiding the scanning operation on complete image.

3. EXPERIMENTAL RESULTS

Although the technique presented in the previous section is primarily designed to remove ghost objects from background segmentation outputs, it can also be used to track stationary objects in severe weather and lighting conditions. To back our argument, we have tested the proposed method on over 6 hours of data sequence from i-Lids Parked Vehicle dataset [13]. This dataset has been selected as it is mainly shot in outdoor environment with sudden change in lighting conditions. The testing algorithm is required to detect any car parked for over 60 seconds within the scene.

A simple GMM based segmentation method is tested against the edge orientation based method to see the affect of the proposed method on ghost removal problem. The GMM based method was first tested on 9 different scenarios. Out of 105 genuine events the GMM method picked up 99 events along with 56 ghost objects (false detections), where as the new edge orientation based method picked up only 18 ghost objects. The results obtained are presented in Table 1 and show the effectiveness of the method when compared against the GMM.

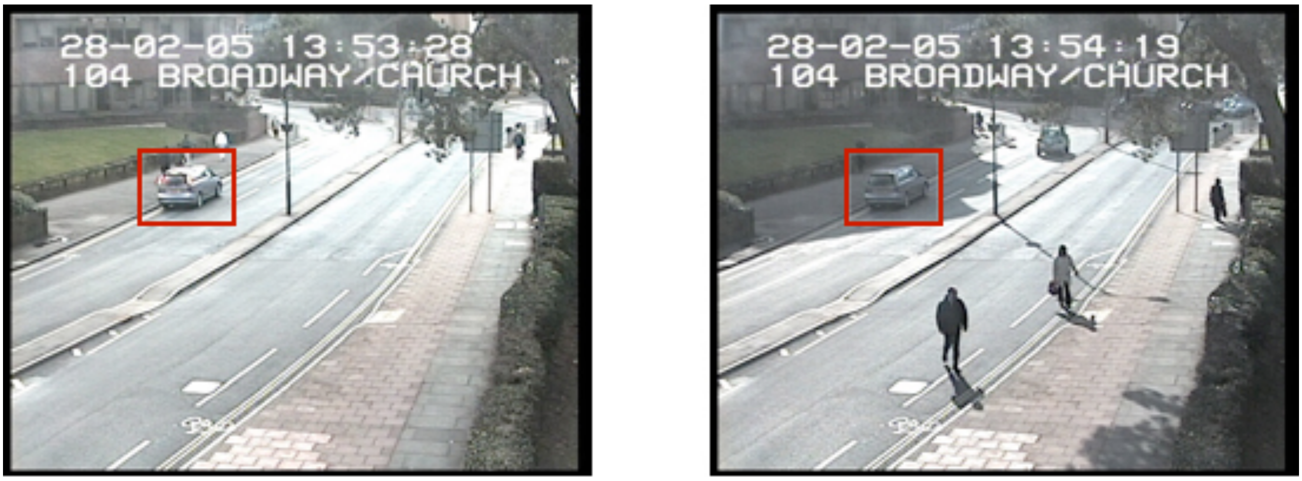
Table 1: Results obtained after testing the proposed edge orientation method against the GMM for ghost detection on the i-Lids dataset of Parked Vehicle.

File Name	Duration (hh:mm:ss)	Total Events	Ghost Objects	
			GMM	Edge Orientation
PVTEA101a	01:21:29	26	21	4
PVTEA101b	00:24:40	8	2	0
PVTEA102a	00:51:56	18	13	6
PVTEA103a	01:03:54	16	4	1
PVTEA201a	00:18:50	4	1	1
PVTEA202b	01:05:23	17	9	2
PVTEA301a	00:15:29	3	1	2
PVTEA301b	00:28:07	7	3	1
PVTEA301c	00:27:09	6	2	1
Total	**06:16:57**	**105**	**56**	**18**

The technique has also been tested to see which object feature remains consistent in severe lighting changes. For this purpose, colour [11], edge magnitude [12] and edge orientation (proposed method) has been tested. The test is carried out on the data sequence shown in Figure 2. The results are compared with two other tracking techniques based on colour by Piccardi *et al.* [11] and edge energy [12]. The running average variations in matching over 800 frames are presented in Figure 3. It can be seen from Table 1 that the matching results obtained from the proposed solution are consistently better than the other two techniques throughout the sequence, especially when there is a large change in the illumination conditions.

Table 2: Running average matching results after applying the adaptive edge orientation based technique; I-MCHSR and edge energy based tracking techniques on data sequence shown in Figure. 2.

Frame Number	Proposed Method	Edge magnitude Hassan *et al.* [12]	I-MCHSR Piccardi *et al.* [11]
900	99.20%	72.36%	80.00%
1200	92.32%	57.54%	72.71%
1400	90.09%	53.36%	62.04%
1700	88.68%	50.89%	58.73%



Frame 600 **Frame 1500**

Figure 2: Data sequence showing change in illumination conditions. The tracked object is marked in Red.

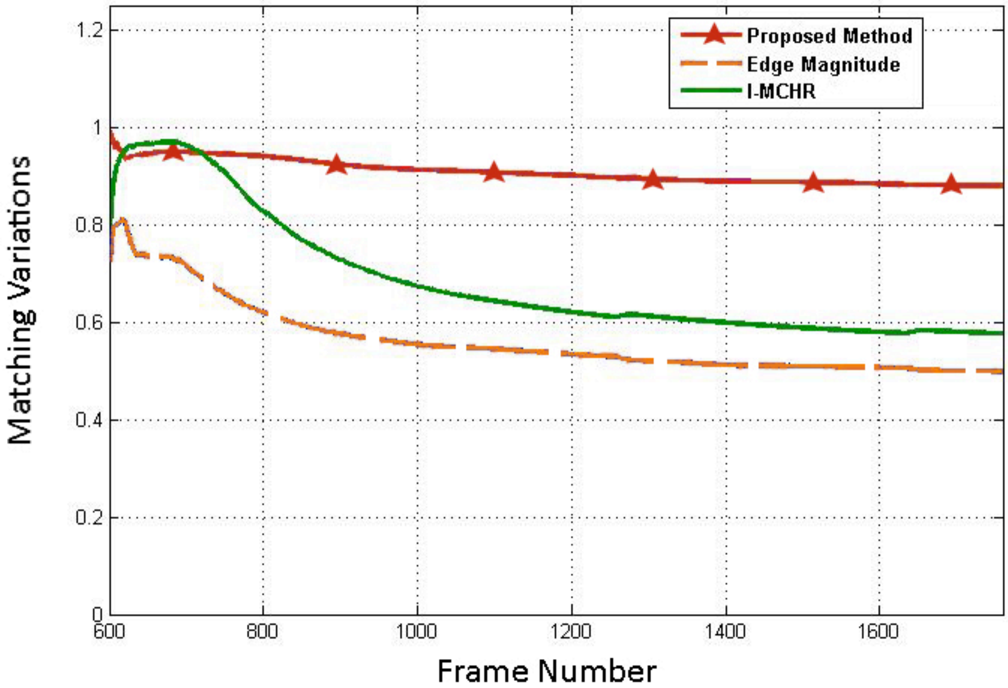


Figure 3: Running average variation in matching from frame 600 to frame 1800 for the three tracking techniques indicated.

It can be seen from the results presented in Table 2, that although there is huge change in lighting condition the proposed method still gives over 85% matching results as compare to 50% and 58% matching results obtained from edge magnitude based and I-MCHSR colour based methods respectively.

4. CONCLUSION

An improved background segmentation method has been presented in this paper to remove the ghost objects from the segmentation output in changing lighting conditions. An edge orientation based method has been proposed where the direction of the edge is utilized to find the similarity between images at different points in time. The experimental results have shown that the proposed method cannot only be used to remove false background areas being highlighted by foreground, but it can also be used to track object in severe lighting conditions with over 85% matching results.

REFERENCES

[1] Kim K, Chalidabhongse T.H., Harwood D, Davis L.S., "Real-time foreground-background segmentation using codebook model," RealTime Imaging 2005, 172-185 (2005)

[2] Stauffer C. and Grimson W.E.L., "Adaptive background mixture models for real-time tracking," IEEE Computer Society Conference on Computer Vision and Pattern Recognition, pp.2 (1999)

[3] Li L., Huang W., Gu I.Y.H., Tian Q., "Foreground Object Detection from Videos Containing Complex Background," Proceedings of the 11th ACM International Conference on Multimedia, Berkeley, CA, USA. November 2003, 2–10 (2003)

[4] Porikli F., Ivanov Y. and Haga T., "Robust Abandoned Object Detection Using Dual Foregrounds," EURASIP Journal on Advances in Signal Processing, vol. 2008, 1-10 (2008)

[5] Reddy V., Sanderson C. and Lovell B.C., “Robust Foreground Object Segmentation via Adaptive Region-Based Background Modelling,” 20th International Conference on Pattern Recognition (ICPR), 3939-3942 (2010)
[6] Zhao C., Wang X., Cham W., "Background Subtraction via Robust Dictionary Learning," EURASIP Journal on Image and Video Processing, Volume 2011 , Article ID 972961, (2011)
[7] Wang L. and Yung N.H.C., “Extraction of Moving Objects From Their Background Based on Multiple Adaptive Thresholds and Boundary Evaluation,” IEEE Transactions on Intelligent Transportation Systems, vol.11, no.1, 40-51 (2010)
[8] Srinivasan K., Porkumaran K. and Sainarayanan G., “Improved background subtraction techniques for security in video applications,” 3rd International Conference on Anti-counterfeiting, Security, and Identification in Communication, 114-117 (2009)
[9] Cucchiara R., Grana C., Piccardi M., Prati A., “Detecting moving objects, ghosts, and shadows in video streams,” IEEE Transactions on Pattern Analysis and Machine Intelligence, vol.25, no.10, 1337- 1342 (2003)
[10] Hwiseok Yang, Yunyoung Nam, We-Duke Cho, Yoo-Joo Choi, “Adaptive Background Modeling for Effective Ghost Removal and Robust Left Object Detection,” 2nd International Conference on Information Technology Convergence and Services (ITCS), 1-6 (2010)
[11] Piccardi M., Cheng E.D., “Multi-Frame Moving Object Track Matching Based on an Incremental Major Color Spectrum Histogram Matching Algorithm,” IEEE Computer Society Conference on Computer Vision and Pattern Recognition - Workshops, 19-19 (2005)
[12] Hassan W., Mitra, B., Chatwin, C., Young, R., Birch, P., “Illumination invariant method to detect and track left luggage in public areas,” Proc. SPIE 7696, 76961V (2010)
[13] i-LIDS dataset, United Kingdom Home Office dataset. Available at http://www.homeoffice.gov.uk/science-research/hosdb/i-LIDS/